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Age at First Calving and Factors Influencing it in Dairy Heifers Kept by Smallholder Farmers in Southern Malawi

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Abstract

Delayed age at first calving (AFC) is known to decrease productivity in dairy cattle. In the present study, we investigated AFC in heifers kept by smallholder farmers in southern Malawi and the reproductive factors influencing it. Data were obtained for 1,620 heifers over a 13-year period from 1999 to 2012. The age at first service (AFS), first service to conception interval (FSCoI), number of services per conception (NSC), conception rate (CR) and service interval (SI) were investigated in relation to AFC. The median AFC was found to be 41 months. This is a relatively high value and shows no improvement from the values reported in the 1970s and 1980s. The median AFS was also high (23 months). Overall, the 1st service CR was 42%, and the median SI was 83 days. AFS appeared to be the most crucial factor that affected AFC. A lengthy SI in combination with a low CR was found to be the critical factor that delayed AFC in heifers that had failed to conceive on previous occasions. These results suggest that the appropriate reproductive management of heifers, particularly initiating the first service at the optimum time and shortening the SI, is necessary for improving dairy productivity.

Discipline: Animal industry
Additional key words: age at first service, conception rate, service interval

Introduction

Dairy farming has become an integrated part of smallholder farming in the highland area of southern Malawi since being introduced there during the 1970s and 1980s (Mussa et al. 1986). Typical smallholder farmers keep a few Holstein x Malawi Zebu crossbreed cattle in small corrals in their backyards, along with small patches of land where staple crops and vegetables are grown (Banda et al. 2012, Tetsuka et al. 2012). Animals are fed crop residues, cut-and-carry roadside grasses, and maize flour (Agyemang & Nkhonjera 1990, Munthali 1993). Despite the widespread use of improved dairy breeds, dairy productivity remains low (Agyemang & Nkhonjera 1990, Mwenya 1992, Banda & Kamwanja 1993, Munthali et al. 1993, Chintsanya et al. 2004, Imani Development Consultants 2004, Banda et al. 2012). Among the various factors responsible for this problem, the timing of first calving is a particular problem that affects milk production and long-term profitability. Delayed first calving increases the cost of rearing and decreases lifetime milk production (Van Pelt et al. 2016). In African countries, delayed first calving is a serious problem where age at first calving (AFC) in excess of 3 years is common (Mugerwa 1989). Delayed first calving has also been reported in Malawi (Agyemang & Nkhonjera 1986, 1990, Munthali et al. 1993, Chagunda et al. 2004). However, these data were collected from the 1970s to the 1990s and may not reflect the current state of dairy farming. Therefore, in the present study, we investigated

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1) the current status of AFC, and 2) the reproductive indices affecting AFC, such as the age at first service (AFS), conception rate (CR), and service interval (SI) in dairy heifers kept by smallholder farmers in the highland area of southern Malawi, the largest milk-shed area of the country (Banda et al. 2012).

Materials and methods

1. Collection of data and associated information

The datasets used in the present study were provided by the Shire Highlands Milk Producers Association (SHMPA). These datasets contained breeding records on 2,210 heifers and cows from 1,686 farmers belonging to 24 milk-bulking groups over a 13-year period from February 1999 to February 2012. Breed information was available for 1,908 cattle of which, 45.7% (n=871) were 1/2 and 41.4% (n=789) were more than 3/4 crosses of dairy breeds and indigenous Malawi Zebu; most were Holstein-Friesian crosses (1/2; n=789, 3/4; n=693) with a small number of Jersey crosses (1/2; n=82, 3/4; n=4) and Afrikander and other crosses (1/2; n=12). The rest were pure Holstein-Friesian (n=318) and Jersey (n=10).

Information on breeding was also provided by the SHMPA. The target age for the first service is advocated to be 18 months, an age when heifers are expected to reach around 300 kg for Holsteins and 275 kg for crossbreeds. Both artificial insemination (AI) and natural service were used as breeding methods. Of 1,097 services given to 567 heifers, 64.7% (n=710) used AI and 35.3% (n=387) used natural service. Of these heifers, 62.3% (n=353) used only AI, 30.3% (n=172) used only natural service, and 19.6% (n=111) used both. AI service was provided by an assistant veterinary officer (AVO) and farmer AI technicians, while natural service was provided by nearby farmers using unproven bulls. Pregnancy diagnosis (PD) was performed by the AVO and AI technicians using rectal palpation on an irregular basis.

2. Data processing

In the present study, breeding records on 1,861 heifers from 1,558 farmers were used. Initially the date of birth, first service and calving were obtained for each heifer, and AFC, AFS, and the first service to calving interval (FSCvI) were calculated. CR was calculated by dividing the number of successful services by the number of total services: a service that resulted in calving or a positive PD and was counted as conceived, whereas a service resulting in a negative PD or a further service was counted as not conceived. To examine the relationships between various reproductive indices, only heifers with complete service records (numbers and dates of all services) were selected from the available datasets. Hereafter, these data are referred to as the “selected” data, whereas the rest of the data are referred to as the “overall” data. Subsequently, the first service to conception interval (FSCoI), number of services per conception (NSC), conception rate (CR), service interval (SI), and gestation period (GP) were calculated (n=184). When PD data were available, the interval between the previous service and PD was calculated (SPDI). Information on breeds was also obtained from the records.

3. Statistical analysis

Data were presented as median, 1st and 3rd quartiles, and mean ± SD. Mean values were compared by using the Mann-Whitney U test or Kruskal–Wallis one-way ANOVA (KW test), followed by Steel-Dwass multiple comparison test (SD test). Percentage data were compared using a chi-squared test. Spearman’s rank correlation coefficients were computed to assess the relationship between two variables at a time among AFC, AFS, FSCoI and NSC. All statistical analyses were conducted using the computing environment R (R Development Core Team 2010).

Results

1. Age at first calving

AFC data were available for 1,620 heifers from 1,999 to 2012. The median, first and third quartiles, and

Table 1. Changes in the age at first calving in heifers from 2000 to 2011

	Age at first calving (months)	
Year	n	Mean ± SD
2000	16	37.3 ± 9.2 [abcde]
2001	55	41.2 ± 14.6 [bcde]
2002	38	48.9 ± 16.2 [ab]
2003	49	51.1 ± 16.2 [a]
2004	121	41.2 ± 12.2 [be]
2005	99	47.1 ± 13.5 [abc]
2006	105	43.5 ± 15.1 [abcde]
2007	92	39.0 ± 11.3 [b]
2008	177	41.3 ± 14.6 [be]
2009	255	45.0 ± 12.8 [abcd]
2010	253	44.6 ± 14.6 [abcde]
2011	318	42.0 ± 12.5 [bde]
Total	1578	43.4 ± 13.8

Significant differences were found between groups with different superscript letters ($P < 0.05$).

the mean ± SD of AFC were found to be 41.2, 33.5, 50.2, and 43.2 ± 13.7 months, respectively. The change in AFC was obtained for 1,578 heifers from 2,000 to 2011. AFC varied substantially over the period with no clear signs of consistent improvement. A significant difference was observed between the years as determined by the KW test (P < 0.001). Significant differences were also noted among years as determined by the SD test (P < 0.05, Table 1).

2. Age at first service

AFS data were available for 500 heifers from 2,002 to 2012. The median, first and third quartiles, and the mean ± SD of AFS were found to be 23.1, 18.5, 30.0, and 25.2 ± 9.5 months, respectively. The change in AFS was obtained for 494 heifers from 2,003 to 2011. There was a significant difference between years (KW test, P < 0.001). However, no significant difference was found between any year groups (SD test, Table 2).

3. First service to calving interval

FSCvI data were available for 331 heifers. The median, first and third quartiles, and the mean ± SD of FSCvI were 11.0, 9.2, 17.1, and 14.3 ± 7.2 months, respectively.

4. Conception rate

The overall first service CR (1st CR) was calculated using data on 567 heifers and found to be 42.0% (n=238). The CR of heifers given AI and natural service were 34.8% (123/353) and 53.7% (115/214), respectively.

5. Service interval

SI was calculated for 378 cases in 192 heifers where two consecutive service dates were available. The median, first and third quartiles, and the mean ± SD of SI were found to be 82, 41, 141, and 107.0 ± 92.3 days, respectively.

6. Reproductive indices of the selected group in comparison with the overall group

To determine whether AFC, AFS, SI, and 1st CR of the selected group represented the overall population, these indices were compared between two datasets. There was no significant difference in AFS and SI between the selected and the overall datasets. However, significant differences were found in AFC and the 1st CR between the two groups (P < 0.001, Table 3).

7. Relationship among AFC, AFS, FSCoI and NSC in the selected group

There were strong positive correlations between AFS and AFC, and NSC and FSCoI (P < 0.001, Table 3). Weaker but nevertheless significant correlations were also found between FSCoI and AFC, and between NSC and AFC (Table 4).

Table 2. Changes in the age at first service in heifers from year 2003 to 2011

	Age at first service (months)	
Year	n	Mean ± SD
2003	17	20.5 ± 3.8
2004	12	25.0 ± 9.2
2005	22	31.6 ± 14.2
2006	31	25.7 ± 9.8
2007	62	27.9 ± 10.3
2008	97	25.9 ± 11.3
2009	54	23.5 ± 8.1
2010	101	23.5 ± 8.1
2011	98	25.2 ± 9.5
Total	494	25.2 ± 9.5

Table 3. Comparison of reproductive indices in heifers between overall and selected data

	AFC (months)	AFS (months)	SI (days)	1st CR (%)
Overall results†	43.2 ± 13.7	25.2 ± 9.5	107.0 ± 92.2	42
(n)	(1620)	(500)	(379)	(567)
Selected results‡	35.0 ± 9.1	24.7 ± 8.3	98.8 ± 65.3	75
(n)	(184)	(184)	(69)	(184)
Significance	P < 0.001	*NS*	*NS*	P < 0.001

†Overall results were obtained by extracting all usable data from the original breeding records. ‡Selected results were obtained from heifers with complete service records (number and date of services), AFS and AFC.

8. Conception rate and service interval in dairy heifers

The CR at the 1st to 5th services varied between 50% and 100% for the heifers in the selected group, with an overall CR of 72.9%. The breeding methods at the 1st service were identified in 177 heifers. The CR of these heifers was 70.8% (85/120) for AI and 82.5% (47/57) for natural service. A total of 69 SI data were obtained for 46 heifers. The median, first and third quartiles, and the mean ± SD were found to be 89, 45, 140, and 98.8 ± 65.3 days, respectively. There was no significant difference in SI between services (Table 5).

9. Pregnancy diagnosis

The dates of PD were available for 58 heifers. The median, first and third quartiles, and the mean ± SD of SPDI were 93, 73, 109 and 101.5 ± 59.0 days, respectively, within a range of 40-164 days.

Discussion

An analysis of 1,620 heifers over a 13-year period from 1999 to 2012 revealed that the median AFC was 41 months. The yearly AFC records from 2000 to 2011 demonstrated that the mean AFC varied substantially from 37 to 51 months with no signs of improvement over the period. These results indicate that AFC had not been improved since the 1970s and the 1980s, when the mean AFC was reported to be 32-40 months (Agyemang & Nkhonjera 1986, 1990, Munthali et al. 1993, Chagunda et al. 2004).

AFC is determined by two factors, AFS and FSCvI, the latter of which is effectively determined by FSCoI, because GP is fairly constant being at around 9 months. FSCoI, in turn, is determined by NSC and SI. In the present study, we focused on these reproductive indices and examined the relative importance of these factors in influencing AFC. For this purpose, two datasets, one consisting of all usable records (overall data) and the other consisting of only selected records (selected data) were used. Significant differences between the two datasets in AFC and the 1st CR, but not in AFS and SI indicate that a selective bias was introduced by the selection of data. This will be discussed in a later section.

As expected, highly significant positive correlations were found in the present study between AFS and AFC, FSCoI and AFC, and NSC and FSCoI. An apparent lack of correlation between AFS and FSCoI also indicates that these factors affect AFC independently.

With the median FSCvI of 11 months and estimated GP of 9.1 months, the median FSCoI can be estimated in the present study to be around 2 months. This means that roughly 50% of heifers achieved pregnancy within 2 months after the first service. The first service CR was 42% for the overall data and 75% for the selected data, indicating that AFC was solely determined by AFS in these heifers. Taken together, these results imply that delayed AFS, rather than prolonged FSCoI, was the

Table 4. Relationship among age at first calving (AFC), age at first service (AFS), first service to conception interval (FSCoI) and number of service per conception (NSC) in heifers

Variables (n)	Spearman's rank correlation coefficients (Significance)				Mean ± SD
	AFC	AFS	FSCoI	NSC	
AFC (184)	1				35.0 ± 9.1 (months)
AFS (184)	0.949 ($P < 0.001$)	1			24.7 ± 8.3 (months)
FSCoI (184)	0.315 ($P < 0.001$)	0.054 (*NS*)	1		1.2 ± 2.9 (months)
NSC (184)	0.295 ($P < 0.001$)	0.041 (*NS*)	0.753 ($P < 0.001$)	1	1.38 ± 0.76

Table 5. Conception rate and service interval in the selected heifers

Service No	1	2	3	4	5	Total
No, of heifers served	184	46	17	4	2	253
No. of heifers conceived	138	29	13	2	2	184
CR (%)	75.0	63.0	76.5	50.0	100.0	72.9
SI (days: mean ± SD)	-	101.1 ± 65.0	100.1 ± 73.4	74.5 ± 27.9	85.0 ± 32.0	98.8 ± 65.3

important factor affecting AFC.

The median AFS was 23 months in the present study. Less than one quarter of the heifers had been served by 18 months (i.e. AFS recommended by the SHMPA), indicating that the first service was delayed considerably. Similarly to AFC, there was no sign of improvement in AFS over the period of 2003-2011.

Prolonged FSCoI becomes a severe problem when a heifer fails to conceive early on. This is especially true for the bottom 25% of the heifers where FSCoI often exceeded more than one year. The selected results revealed that the first and successive service CRs were approximately 70% and more than 95% of the heifers had conceived after the first three services, indicating a fairly good CR in these heifers. The average SI between two successive services was around 3 months. In an ideal situation, when a heifer fails to conceive, it returns to estrus in about three weeks and is served again, which would make the SI around 21 days. Our results indicate that the heifers on average missed four to five service opportunities per each failed service. With a lower overall CR, a long SI would extend FSCoI and further delay AFC. In this situation, reducing the SI becomes the primary target for hastening AFC. Taken together, these results indicate that the proper management of AFS and SI is the key to improving dairy productivity.

The most likely reason for the delayed first service is the slow growth of heifers (Duplessis et al. 2015). The optimum body weight at the first service is considered to be around 300 kg for Holsteins and 275 kg for crossbreeds in Malawi. Since most dairy cattle in the present study were pure Holsteins or Holstein crosses, they should have reached more than 275 kg at the first service. Although data on growth rate or body weight at the first service were not available in the present study, it is likely that the majority of heifers had not reached the target weight by the age of 18 months. In an earlier study, we roughly estimated the age at which the heifers reached 300 kg using weight records. The results predicted that less than 15% of heifers could reach 300 kg by the age of 18 month (Tetsuka et al. 2012). This result is in accordance with the present results showing that less than 25% of heifers were served by the age of 18 months. The growth rate of heifers in tropical regions has been previously reported as low, especially on a low plane of nutrition (Mugerwa 1989, Ugarte 1991, Moss 1993, Perera 1999). A further study is necessary to establish the relationship between AFS and the body weight or growth rate of heifers kept by smallholder farmers.

One of the most likely causes of a prolonged SI is an inappropriate estrous detection (Firk et al. 2002). Most farmers in the area lack appropriate knowledge about estrus and its detection (Tetsuka et al. 2012). Rather than detecting estrus themselves, the farmers normally wait for PD to be done by an AI technician or extension staff, generally about 3 months after the service (Banda et al 2012). The results obtained in the present study, where 50% of PD was conducted between 73 and 109 days after the service, agree with these findings. The average SI was also around 3 months in the present study. Taken together, these results imply that the timing of PD is an important factor that determines the length of SI. A further study of this subject will benefit farmers by helping them to improve the reproductive efficiency of their cattle.

The other reason that increases the SI is an insufficient AI service (Banda et al 2012). Currently, a small number of AI technicians have to cover a large number of widespread farms. Thus, even if a farmer detects estrus properly, an AI technician may not be able to reach the site in time. As expected, the 1st CR after AI was lower than that of natural service in both overall and selected groups in the present study. Nevertheless, two-thirds of the heifers were bred by using AI, indicating AI had been well propagated among the farmers. For improved reproductive efficiency, it is necessary to improve the skills of AI technicians and increase the number of AI technicians.

As mentioned above, two datasets were used in the present study. There were significant differences between the datasets: AFC of the selected heifers was more than 8 months shorter than that of the overall sample, whereas CR was nearly twice as high. This discrepancy indicates that heifers with complete breeding records performed better than heifers without such records. In other words, the heifers under better reproductive management had a better chance of conceiving earlier. In general, the birth dates and dates of first calving were recorded for the majority of heifers, whereas the service records, especially for the second and any subsequent services, were often missing. The lack of information about the last service is likely to negatively affect the outcome of a following service. These results also suggest that a careful approach should be taken when analyzing breeding records, as such records might contain biased or missing data.

Nevertheless, breeding records provide valuable reproductive performance information to smallholder farmers and present opportunities to improve reproductive efficiency. Precise record keeping is one of the key factors for improving dairy productivity (Kosgey et al. 2011), and it should be encouraged among farmers and extension workers.

In conclusion, AFC had not been improved for the last 30-40 years in heifers kept by smallholder farmers in southern Malawi. The delayed first service appears to be the prime cause of delayed first calving. A lengthy SI in combination with a low CR becomes a critical problem when heifers fail to conceive during earlier services. Farmers must ensure that the first service is initiated at the optimum time, and that follow-up services are carried out earlier, which would shorten the SI. Such improvements in reproductive management are likely to go a long way towards increasing productivity by reducing the cost of rearing and increasing lifetime milk production.

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